[redacted]

dward-Clyde

Memorandum

To: Dolly Potter
Solvay Minerals

THE ATTACHED PORTIONS OF THE EPA, MAY 1995, DOCUMENT pertain to our DISCUSSION OF low CONCENTRATION VOC STREAMS.

PLEASE NOTE THE LAST TWO pages which references INSTALLED SYSTEMS.

Appendix B provides some COST Numbers (FOR 10,000 SCFM systems) controlling either 10 or 100 ppm STREAMS.

TO ADDRESS THIS, WE will NEED TO:

- OBTAIN INFORMATION FROM EXISTING plants REGARDING VAPOR STREAM (TEMP, moisture content, etc.) + OPERATING COSTS, AND specific VOC's Treated
- ASSESS THE DESTRUCTION REQUIREMENTS FOR YOUR VAPOR STREAM, (TEMP. required, affect of UV, AFFECT OF PARTICULATES, etc)

OR, WE CAN STAY WITH THE NARROW "BACT" VIEW that technology has not been applied to This INDUSTRY FOR CONTROL OF VOC.

I will call you MONDAY -

David

EPA-456/R-95-003

May 1995

Survey of Control Technologies for Low Concentration Organic Vapor Gas Streams

Prepared by:

Robert A. Zerbonia
James J. Spivey
Sanjay K. Agarwal
Ashok S. Damle
Charles W. Sanford
Research Triangle Institute
Research Triangle Park, NC 27709

EPA Contract No. 68-D1-0118
Work Assignment No. 114
RTI Project No. 5846-114

Project Manager

Robert J. Blaszczak
Information Transfer and Program Integration Division
Office of Air Quality Planning and Standards
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Prepared for

Control Technology Center
U.S. Envionrmental Protection Agency
Research Triangle Park, NC 27711

EPA REVIEW NOTICE

This report has been reviewed by the Control Technology Center (CTC) established by the Office of Research and Development (ORD) and the Office of Air Quality Planning and Standards (OAQPS) of the U.S. Environmental Protection Agency (EPA), and has been approved for publication. Approval does not signify that the comments necessarily reflect the view and policies of EPA, nor does mention of trade names, organization names, or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia, 22161, (800) 553-6847.

This document was funded by EPA's Control Technology Center and prepared by Research Triangle Institute (RTI). This document is the result of a request for technical assistance from the State and Territorial Air Pollution Program Administrators and the Association of Local Air Pollution Control Officials (STAPPA/ALAPCO) to identify control technologies that are effective on treating gas streams with low concentrations of volatile organic compounds (VOC) and/or organic hazardous air pollutants (HAP). This document presents the results of a series of studies conducted to identify commercially available control technologies applicable to low organic concentration gas streams. Technical and economic background information relevant to the control technologies is presented by technology type. Performance of the air pollution control devices is documented in the form of source test reports or permits issued by State or local air pollution control agencies. The document with the information and data presented provides the basis for evaluating the availability and efficacy of air pollution control devices in reducing organic emission in low concentration, high flow rate gas streams.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

SECTION 1
INTRODUCTION

1.1 BACKGROUND

A commonly applied approach to control of organic vapor emissions from stationary or point sources is the application of add-on control devices. Several different air pollution control technologies can be applied to sources of organic air emissions (once they are covered, enclosed, or vented) to recover or destroy the pollutants. In general, application of a particular technology depends more on the emission (gas) stream under consideration than on the particular source type. Selection of applicable control techniques for point-source organic emission abatement is made for the most part on the basis of stream-specific characteristics and the desired control efficiency. A key stream characteristic that affects the applicability of a particular control technology is the concentration of organics in the gas stream.

This document presents the results of a series of studies conducted to identify commercially available control technologies suitable for application to low organic concentration gas streams. Initially, OAQPS's Emmision Standards Division conducted a study to survey and document the performance of control technologeis applicable to gas streams containing low concentrations (i.e., less than 100 ppm) of organic vapors* (see EPA-RTI contractor report, "Survey of

---

*The term "organic vapors" (OV) is used in this report to characterize the broad range of organic compounds that might be found as constituents in a gas stream that is vented, exhausted, or otherwise emitted to the atmosphere. The term "OV" as used in this report would generally include those organic constituent categories that are specifically defined and carry a precise statutory or regulatory denotation (e.g., "volatile organic compounds" [VOC] as defined in part 51 of Title 40 of the *Code of Federal Regulations*; "hazardous air pollutants" [HAP] as identified in Title III, Section 112(b), of the Clean Air Act Amendments of 1990; or "volatile organics" [VO] as measured by Method 25D, 59 FR 19402, April 22, 1994).

Control Technologies for Low Concentration Gas Streams," Research Triangle Institute (RTI) September 1993). The study also evaluated technical and economic aspects of control systems specifically designed for low organic concentrations. To the extent possible, results of source tests reflecting operation of the control technologies at actual facilites were used as the primary source of documentation of performance. However, at that time, there was very little available information on field tests of technologies in use on low organic concentrations gas streams. In many cases, manufacturers claims on the effectiveness of the technologies were not supported by test data. As a result, the actual test data included in the original report were limited. In this first phase of the work, information and data were obtained from various offices within the EPA including the Office of Air Quality Planning and Standards; the Office of Research and Development, and the Office of Solid Waste; the EPA Regional Offices; several State and local air pollution control agencies; and numerous equipment manufacturers and vendors. Appendix A presents a list of the organizations contacted regarding control technologies for gases containing low organic concentrations.

As a continuation of the initial work in this area, the EPA's Control Technology Center (CTC) supported a study to identify control technologies that have been documented effective on low concentration/high volume flow streams. The work was presented as an appendix to the original report, i.e., Identification of Permitted Control Technologies for Low Concentration Gas Streams, as a continuation of EPA's work in this area and utilized the material and knowledge gained in compiling the original report, (i.e., "Survey of Control Technologies for Low Concentration Gas Streams," RTI, September 1993). The object of the second phase of the study was is to identify permitted control devices that have been installed and demonstrated to be effective for low concentration organic vapor (OV) gas streams, particularly those with high air flow rates. Low concentration is assumed to mean 100 ppm or below, although some control devices currently controlling higher OV concentrations are included if they are feasible for lower concentration OV gas streams or are of particular interest. High flow rates are assumed to be those above 100,000 cfm, although some devices currently controlling lower flow OV gas streams are included. The demonstration of control device performance is either in the form of source test reports or permit conditions issued by State or local air pollution control agencies. In this second phase of the study, information and data were obtained primarily from two sources. First, equipment manufacturers and vendors were contacted in order to identify locations where low concentration/high flow rate devices have been installed and tested. Next, State and local air pollution control agencies were contacted to request both permit and source test information on these particular devices.

Permitted control devices are presumably associated with Federally enforceable pollutant reductions, and include devices that are installed on full-scale facilities rather than bench-scale applications. Devices installed pursuant to a consent order prior to permitting are also included.

The performance of some of these air pollution control devices has been documented through a compilation of source tests and those results are summarized under the appropriate technology. Source tests in most cases were conducted using reference or equivalent methods, and observed by a representative of an air pollution control agency. Performance results obtained by other test methods are also included in the final report, and such results are noted; however, a rigorous evaluation of each testing protocol was not made as a part of this study.

1.2 SCOPE

Although there are a number of control technologies in use for gases with high organic concentrations, not all are applicable at low concentrations. There are also other technologies which, in principle at least, can remove or destroy organic vapors from gas streams but are less cost effective at low concentrations. For the purposes of this document, technologies such as membranes and recuperative thermal oxidation systems fall into this category. For example, recuperative thermal oxidation is very useful for control of hydrocarbon gases at inlet concentrations of around 1,500 to 3,000 ppm because the heat of combustion of these gases is sufficient to sustain the high temperatures required without addition of expensive auxiliary fuel. At 100 ppm, however, large amounts of auxiliary fuel are needed and recuperative thermal oxidation, though in principle an effective control technique, generally is not economically feasible. Biofiltration, though perhaps applicable to low organic concentration gases, is also not within the scope of this study.[1] A brief description of the biofiltration process is included in Section 5.0 for background information. The technologies that were evaluated for this document include the following:

- incineration
  - catalytic
  - regenerative thermal
- adsorption
  - nonregenerable
  - modified regenerable (including adsorption/incineration)
- absorption
- other commercial technologies
  - UV/ozone catalytic oxidation
  - enhanced adsorption
- emerging technologies
  - corona destruction
  - heterogeneous photocatalysis.

The results of the studies are summarized and presented in this document by technology beginning in Section 2.0. In general, the overall performance of the control technologies was found to be poorly documented relative to EPA standards. For example, the lack of rigorous analyses (using test data) of the inlet and outlet gas compositions in all but a few cases makes a comprehensive evaluation of these technologies difficult.

The cost-effectiveness ($/ton OV removed) of these technologies was calculated using the model gas streams and general methods described by the OAQPS Control Cost Manual.[2] Though cost information for model streams was requested from vendors of all technologies, responses were few. Therefore, to compare the technologies on a common basis, capital and operating costs were calculated using published values and vendor-supplied cost factors to the extent possible on four model gas streams. These were 100 and 10 ppm benzene in air and 100 and 10 ppm tetrachloroethylene in air, all at a flow rate of 10,000 scfm. Estimates of total annualized cost for the various technologies based on the model gas streams are presented in Appendix B.

Because of the uncertainty associated with both the emission reduction and the costs, the accuracy of the cost-effectiveness values in some cases is probably no better than order of magnitude and thus conclusions should not be drawn about relative cost effectiveness when differences are small, e.g., between regenerative thermal incineration and regenerable fixed-bed adsorption for 100 ppm benzene. Overall, cost-effectiveness values range from $2,000 to about $67,000 per ton of OV removed (in 1991 dollars). These relatively high values reflect the very dilute concentrations of interest. As expected, cost-effectiveness values are much higher for lower concentrations.

1.3 CONCLUSIONS

1. The control of low concentration organic gas streams is currently one of the most dynamic segments of the air pollution control technology industry. The technologies as well as their applications are undergoing

rapid change and development. Since originally compiling the information and data for this document, performance data have become more available and most recent indications are that the cost-effectiveness of some of the technologies has improved. For this reason, some of the data and information in the document may be outdated.

2. Commercially available technologies exist for control of gas streams containing less than 100 ppm OV. Destruction and removal efficiencies >99 percent have been demonstrated at a number of sites for each of the technologies discussed here. As expected, the lower the concentration the higher the cost-effectiveness of the controls.
3. Based on the number of commercial installations, adsorption-based processes are most widely applicable to low concentration gases. A recent development by several vendors is the pairing of adsorption and desorption steps that concentrate the OV with a separate step to treat the concentrated OV. These systems are specifically designed for low concentrations.
4. Concentrating adsorption systems (including but not limited to rotary carbon or zeolite absorbers from Dürr and Munters Zeol) are increasingly proposed by vendors in conjunction with incinerators (or other devices) to control low concentration, high flow OV streams. These adsorption systems are more widely demonstrated in Europe, probably because of more stringent regulations.
5. In addition to adsorption-based processes, other technologies are being used specifically for low concentration gases. These include absorption/stripping process and UV/ozone catalytic oxidation. Preliminary evaluation suggests that absorption may be competitive with the more widely used adsorption-based processes at

concentrations close to 100 ppm. Insufficient cost information was available to evaluate the cost effectiveness of UV/ozone technologies.

6. Thermal or catalytic incinerator systems with regenerative heat recovery are being proposed more widely by vendors. Regenerative heat recovery is often more cost effective than recuperative heat recovery for systems with flows above 50,000 scfm.[3] A number of combinations of these regenerative systems are available, although not all are demonstrated at the concentration (and flow rate) examined in this study. Pure thermal oxidizers without heat recovery were not proposed for low concentration, high flow OV streams by any vendor contacted.
7. There is a trend for vendors to collaborate on proposal to provide "best-of-breed" combinations of devices to make up a (case-specific) control system. An example of this is a system proposed using a Dürr rotary concentrator, an Anguil recuperative incinerator, and a Johnson Matthey catalyst. Numerous such systems are proposed and are available with a performance warranty.
8. The development of these modified or hybred systems and devices is proceeding at a rapid pace. These devices are generally installed on new sources or existing sources affected by newly implemented regulation, and so this rapid technological development appears to be largely driven by the implementation of new and existing regulations.
9. Twenty-five (25) control devices for low concentration, high flow OV gas streams are currently known to exist in the U.S. All are either permitted, being permitted, or installed under a consent order. Documentation in the form of permits and source test results was requested for all these devices. A table containing the relevant details on these devices (e.g., inlet concentration, flow-rate, industrial application, and location) is provided in Appendix C.

10. A need exists to more rigorously document the performance of field systems. Reliable and complete inlet/outlet gas composition measurements taken at conditions of practical interest are scarce. Data reported on many field tests are incomplete or inconsistent. In addition, the acquisition of performance data on these devices was hindered by the reluctance of some vendors to disclose the identity of their clients, and the limited access to state and local air pollution control agencies's files.

1.4 RECOMMENDATIONS

1. Further research on documenting the performance of control devices for low concentraiton OV streams with high flows should be conducted; this would include continued gathering of information on field tests of technology in use on low organic concentration gas streams, especially those with high flow rates. Much of the information requested was not received. Therefore, collection of additional permit information and field test data will likely require commitment of resources, e.g., it may be necessary to travel to various local, State, or regional air offices to collect the information directly. Visits to a few State and local air pollution control agencies may be the quickest and least expensive method of gathering such data if detailed and/or extensive documentation is desired.
2. Several of the technologies applicable to low concentration, high flow streams now have a better defined cost history. The capital and annual operating costs reported in the original study were, in large part, based on either EPA estimates or vendor estimates because of the limited number of these technologies in actual field applications in 1991. The number of these devices in full scale operation has dramatically increased over the past few years and many of these

technologies now have several years of operating history. Updated capital and operating cost information could be obtained that would better reflect current actual costs. Additional cost effectiveness studies also could be performed to determine which technologies are most cost-effective for low OV concentrations and high gas flow rates. This may involve formally requesting vendors to develop quotes. Detailed costs were not available for the modified regenerable adsorption systems. The fact that they are being commercially used does, however, suggest that they are of comparable cost to the conventional regenerable systems.

3. Consideration should be given to conducting field tests of some demonstrated devices to better document performance at realistic conditions and as a means of broadening the concept of availability (for use during standards setting). The modified (or hybred) adsorption systems and the alternative design, i.e., horizontal flow, regenerative thermal oxidizers appear to be good candidates for performance testing.
4. There is an increasing number of technologies being applied to control of indoor air pollution in large buildings (e.g., the ozone/catalyst system developed by Union Carbide[4,5]). The very low concentration of indoor air contaminants (typically around 1 ppm) and large flow rates in buildings make these technologies of interest for study. However, these technologies were not evaluated as a part of this study, though they may be of particular interest for concentrations near 1 ppm OV.